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DEFECTS IN TIMBER CAUSED BY INSECTS

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INTRODUCTION

It is extremely difficult to estimate the losses due to defects in timber caused by insects. Where the grade of lumber is lowered, the loss may be ascertained by the reduction in the grade, because of the number or size of the holes caused by insects. However, where entire large oak or spruce trees are left to rot in the forest,

because the wood has pinholes in it and hence is not suitable for high-grade cooperage or airplane stock, the loss is greater, but perhaps more intangible. Where such timber is accessible and there are suitable markets, it need not be an entire loss, but could be used for lower-grade products. Closer utilization is of prime importance in the prevention of waste in the conservation of our forest resources.

Better methods of manufacture and the use of forest products, and the elimination of waste, as advocated by the Federal Forest Products Laboratory at Madison, Wis., and the Bureau of Standards of the Department of Commerce, will go far in helping to relieve the great timber shortage, which is especially serious in the case of the hardwoods.

The purpose of this bulletin is briefly to describe and illustrate, from the viewpoint of the entomologist, for the benefit of graders, inspectors, manufacturers, or utilizers of timber products, the principal types of defects in timber caused by insects, the causes of these defects, and, where possible, the mode of applying recommended methods to prevent the damage and loss. The Forest Service has already published a circular on grading lumber (*39*).[1]

Wood-boring insects not only destroy a considerable quantity of forest products, but also cause the loss of the labor expended during the process of their manufacture. The trees from which these products were cut are a loss, and additional trees must be taken from the forest to replace them. To this loss must be added percentages of the cost and upkeep of lumber camps, machinery, equipment, logging railroads, wages and keep of men and animals in the woods, storage in the mill pond, sawing, drying, finishing, and piling at the mill.

The direct money loss caused by insects to cut timber and lumber assumes an enormous aggregate—greater proportionately than that caused by insects to living timber. To the money loss of production costs must be added the loss of time necessary to properly season the wood.

Of course, damage to seasoned finished wood products causes relatively greater loss than does damage to crude forest products. Where the products are damaged after being put in place, the cost of replacement involves additional loss of labor and time, as well as the cost of the original and replaced products, a loss far greater than the value of the raw products. Often such replacement charges should be charged to both wood-destroying fungi and wood-boring insects and not to one agency alone, as frequently there is a close relationship between these forms of life in the destruction of timber. However, in many cases wood-destroying fungi alone are responsible for the destruction.

It has been demonstrated in practice that a large percentage of the $45,000,000 annual loss (*45*) caused by wood-boring insects in the past can be prevented in the future. The increased prices of lumber and all other forest products make it even more essential that all avoidable waste caused by insect defects should be eliminated in the interest of conservation.

[1] Reference is made by italic numbers in parentheses to "Literature cited," page 44.

In order to accomplish this saving it is necessary for manufacturers of wood products to utilize all available information that has been obtained from experiments carried on for many years by the Bureau of Entomology, especially the results of scientific research on the specific causes of the different types of insect defects and methods of preventing them. Data contained in earlier bulletins by experts of this bureau, as well as new and unpublished data, have been used freely in this bulletin. The published articles by Hopkins (*23*, *24*, *25*, *26*, *27*, *28*, *29*, *30*, *31*, *32*, *33*, *34*, *35*), Burke (*6*, *7*), Webb (*50*, *51*), Craighead (*9*, *10*, *11*, *12*, *13*, *14*), Snyder (*43*, *44*, *45*, *46*, *47*), and St. George (*41*) were the source of much information. The pioneer investigations and publications of Doctor Hopkins, former forest entomologist of the Department of Agriculture, in reality form the basis for this bulletin. Doctor Hopkins's investigations have done much to prevent waste and losses due to insects. References to these and many other publications are to be found in Chamberlin (*8*).

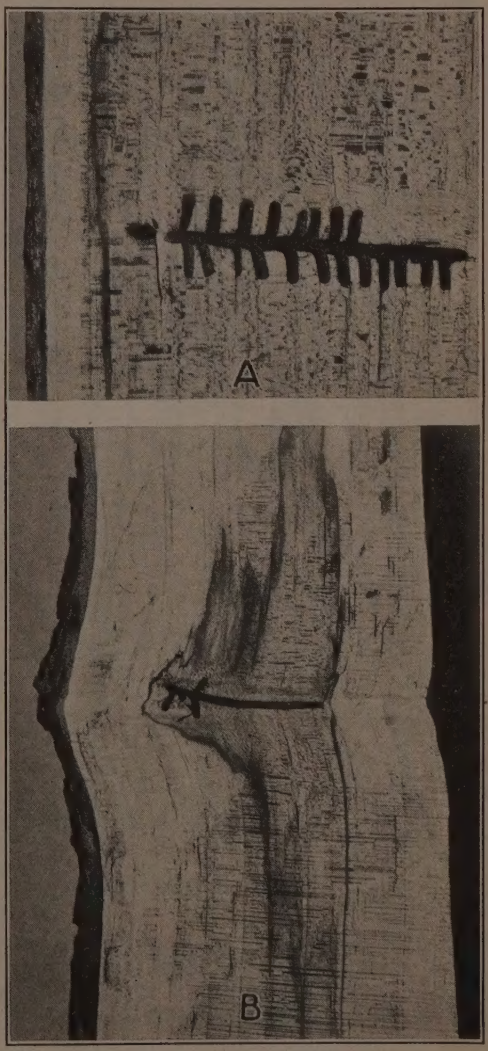

FIG. 1.—Black holes in white oak made by *Corthylus columbianus*. A, slightly enlarged; B, slightly reduced

Timber inspectors and graders should be able to determine from the defect in the wood whether it was caused by insects working in (1) the living tree; (2) the freshly felled, green saw log or bolt, with or without the bark on; (3) the green, unseasoned lumber; or (4) seasoned rough or finished product.

The rejection of timber with insect defects caused in the tree, log, or green lumber before the wood is dry or seasoned is often an avoidable loss, because the insects are no longer working in the wood. This type of insect defect is analogous to "pecky cypress" caused by a fungus. Even though the defects are such that they materially affect the strength of the wood or otherwise unfit it for the special use intended, there are still many purposes for which it can be used. The grade may be merely lowered, according to the number and size of the holes; or the defect may unfit the wood for special uses, owing to unsightly appearance, likelihood to cause leaks (as for barrel staves and heads for tight cooperage), or weakening (as for high-grade airplane stock). Much waste can be avoided by utilizing such defective timber for other uses and in lower grades than originally intended.

FIG. 2.—"Calico poplar," a defect caused by an ambrosia beetle (*Corthylus columbianus*). (25)

Damaged implement or vehicle stock and other material in which great structural strength is required can be used for less exacting purposes, the defect being plugged and painted over; while low-grade lumber with wormholes but no living worms or decay can be used as the base for veneer if the holes are not large enough to cause depressions in the face veneer. On the other hand, the acceptance of material infested by powder-post beetles may lead to serious results through a break at a critical moment.

Special reference is made in this bulletin to the protection and conservation of both crude and finished wood products, such as lumber, bolts, cooperage stock (finished and unfinished), agricultural-implement handles, tent poles, vehicle parts, timber for shipbuilding, oars, airplane stock, and other high-grade products.

TYPES OF INSECT DEFECTS; DEFINITIONS

The principal types of defects caused by insects may be classed in three definite groups, namely, pinholes, grub holes, and powder post. (Table 1.) The terms for these defects are those generally used by the loggers in the woods and the sawyers and graders at the mill.

TABLE 1.—*Classification of the more common defects in timber caused by insects*

Type of defect	Description	How and when made	Condition of defective [1] timber	Preventable
Pinholes	Holes with dark streak in surrounding wood:			
	Hardwoods—			
	Stained area 1 inch or more long	By ambrosia beetles in living tree	Wormholes, no living worms or decay.	No.
	Stained area less than 1 inch long	By ambrosia beetles in recently felled trees and green logs.	do	Yes.
	Softwoods	By ambrosia beetles in sapwood of felled trees, logs, or green lumber.	do	Yes.
Grub holes	Holes alone darkly stained:			
	Larger than one-eighth inch in diameter	By wood-boring grubs in living trees	do	No.
	Smaller than one-eighth inch in diameter	By ambrosia beetles in felled trees, green logs, or green lumber.	do	Yes.
	Holes unstained:			
	Holes circular, open—			
	Holes less than one-eighth inch in diameter	By ambrosia beetles in recently felled green logs or green lumber.	do	Yes.
	Holes more than one-eighth to one-fourth inch in diameter	By timber worms in living trees	do	No.
	Holes oval, with powderlike boring dust or shreds (frass); usually more than one-fourth inch in diameter.	By round-headed borers in recently felled softwoods and hardwoods.	do	Yes.
Powder-posted	Holes unstained, filled with granular or powdery boring dust:			
	Hardwoods	By round-headed borers and powder-post beetles in green or seasoned timber.	Wormholes, no living worms or decay, or powder-posted.	Yes.
	Softwoods—			
	Boring dust tightly packed (pellets of digested and excreted wood).	By flat-headed borers in living or green felled trees.	do	No or yes.
	Boring dust shredded, loose	By round-headed borers in seasoned wood	do	Yes.
Pitch pocket		By various insects in living trees	Wormholes, no living worms or decay.	No.
Black check		By the grubs of various insects in living trees	do	No.
Bluing	Stained area over 1 inch long	By fungus following insect wounds in living trees and recently felled sawlogs.	do	No or yes.
Pith fleck		By the maggots of flies or adult weevils in living trees.	do	No.
Gum spot		By the grubs of various insects in living trees	do	No.
Ring distortions		By defoliating larvae	do	No.

[1] Wormholes, no living worms or decay, is divided into two types: Injury which, from the lumberman's standpoint, can not be prevented, and injury which can be prevented by proper and prompt handling of felled trees. Timber with these defects can be utilized for certain purposes. (See pp. 11, 14, 17, 20, 22, 24, 25.)

Powder-posted or living wormy is a continuous injury, hence timber having this defect can not be used with safety before treatment with chemicals, kiln-drying, or steaming in a kiln. This defect can be prevented by proper handling of the stock. (See pp. 30, 31, 33, 34, 35.)

PINHOLES

Pinholes are small, round, usually open holes ranging from one one-hundredth to one-fourth of an inch in diameter; they are made either by ambrosia beetles or timber worms. Pinholes caused by ambrosia beetles are of two types: (1) Pinholes caused by adult beetles boring into the trunks of growing trees for the purpose of laying eggs and rearing their young, or by larvae, which also may burrow in the wood; (2) pinholes made by adult beetles or larvae in freshly felled green saw logs (with or without the bark on), bolts, and green or partly seasoned lumber.

In commercial grading rules for various species of timber pinholes constitute a standard defect (considering only wormholes), but are sometimes recognized as "equivalent defects," that is, equivalent

FIG. 3.—Work of ambrosia beetles in both sapwood and heartwood of southern yellow pine

to other defects, such as knots. This grade in certain hardwoods is termed "sound wormy" and is of that class of defects in timber or lumber in which the insects are no longer present and hence no further damage results to the timber.

GRUB HOLES

Grub holes or the larger wormholes are oval, circular, or irregular holes three-eighths of an inch to 1 inch in diameter, produced by adult insects (1) boring into or laying eggs in the trunks of living trees, or (2) boring into green, recently felled logs for the purpose of laying eggs or rearing their young; the young or larvae cause most of the injury to the wood, which serves as both food and shelter.

Grub holes may also be classified as standard defects.

POWDER POST

Powder post is that class of defects in which the larvae of insects reduce the wood fibers of seasoned or partially seasoned wood to a powderlike condition by boring through the wood, which is both their shelter and their food.

Powder post occurs only in the seasoned or partially seasoned sapwood or heartwood of both hardwoods and softwoods. Logs, bolts, timbers, lumber, and crude or finished products are attacked. The infested wood is always more or less filled with fine or coarse powdery or granulated boring dust and is called powder-posted. This type of injury is dangerous, since the grubs continue their destructive work in the wood and also infest other timber near by.

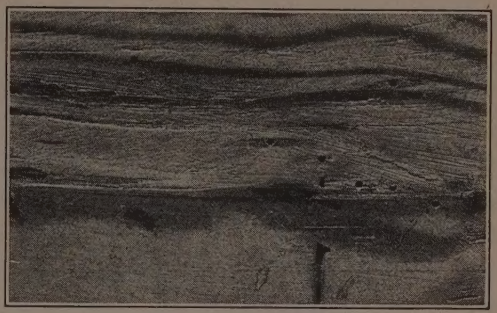

FIG. 4.—Pinholes caused by the pine-wood stainer (*Gnathotrichus materiarius*)

DEFECTS CLASSED AS PINHOLES

The term "pinholes" undoubtedly originated with stave makers and coopers, from the fact that such holes are often plugged with small wooden pins. Pinholes are small, round holes one one-hundredth to one-fourth of an inch in diameter in both the heartwood and sapwood of hard (broad-leafed) and soft (coniferous) living trees, green, moist saw logs, bolts, green timbers, or green piled lumber. These holes are made by either ambrosia

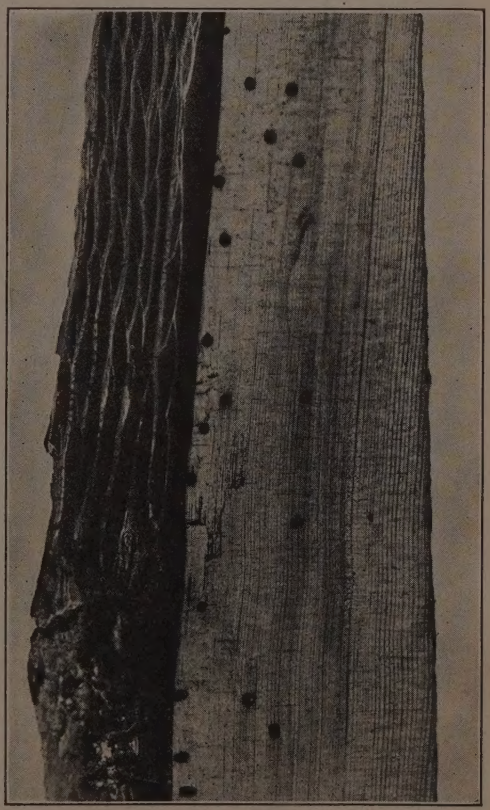

FIG. 5.—Pinholes in sapwood Douglas fir made by *Xyloterus* sp.

beetles or timber worms. In the former case (where caused by ambrosia beetles) the holes are made by both the small, slender, cylindrical, adult beetles, and, after hatching within the wood, by their

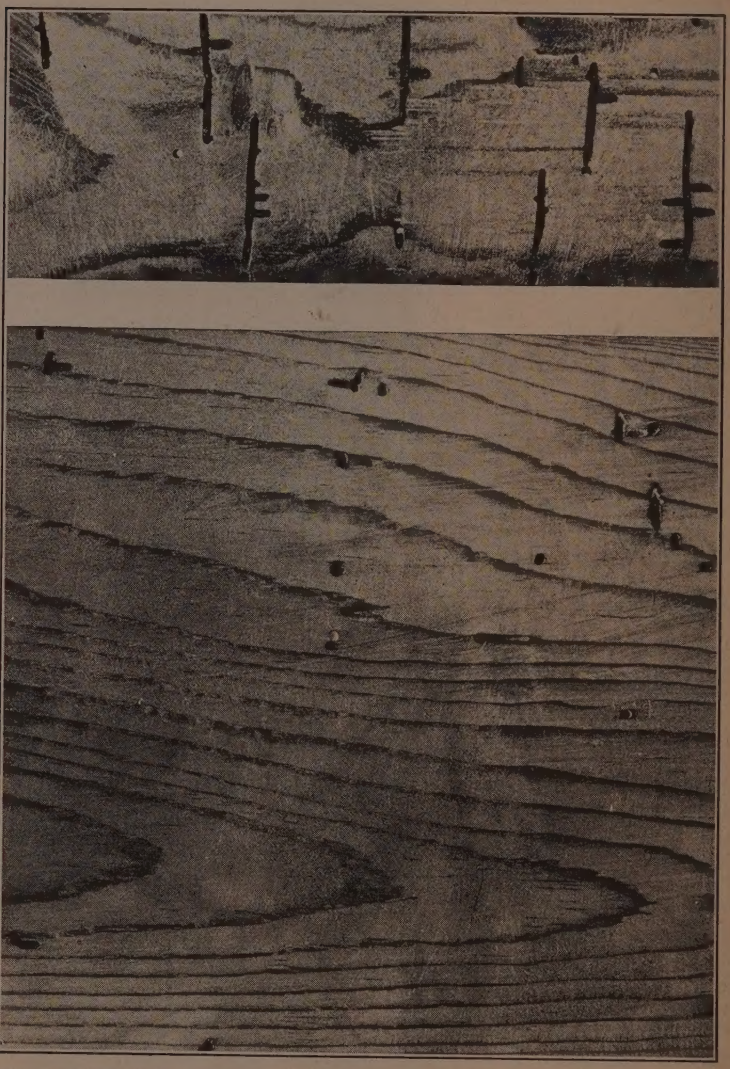

FIG. 6.—Pinholes made by the spruce timber beetle (*Xyloterus bivittatus*) in red spruce, West Virginia

larvae or young. In the latter case the injury is caused entirely by the larvae or grubs (young) of beetles or the so-called timber worms.

The larvae of some types of ambrosia beetles excavate side galleries at right angles to the gallery made by the adult, which tunnels into the wood to deposit eggs; other types excavate no side galleries. Some holes are clear; others are stained black by the action of fungi, some of which the beetles cultivate for food in their

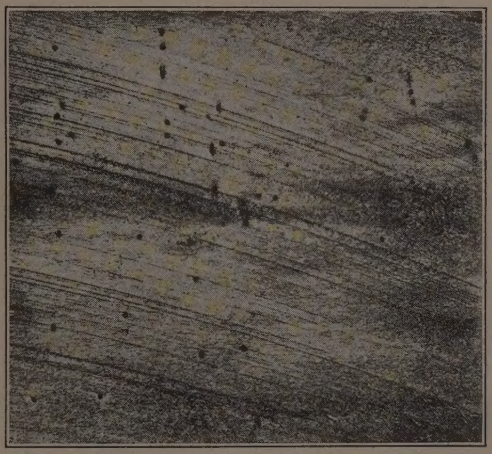

FIG. 7.—Pinholes caused by ambrosia beetles in heading and tight cooperage in South Carolina

FIG. 8.—Pinholes in green hickory lumber caused by an ambrosia beetle (*Xyleborus xylographus*)

galleries. Injury to green heartwood stock and to partly seasoned stock of such woods as hickory and cypress in many cases does not produce the stain.

These holes are always open (never filled with dust), and are either clear or black and associated with discolored streaks or stains

in the surrounding wood. In the latter case, the injury is caused by the larvae or grubs (young) of the beetles.

PINHOLE DEFECTS FORMED IN LIVING TREES; A NONPREVENTABLE LOSS

When pinhole defects occur in the living tree, it is of course impossible for the lumberman to prevent the injury, since the holes

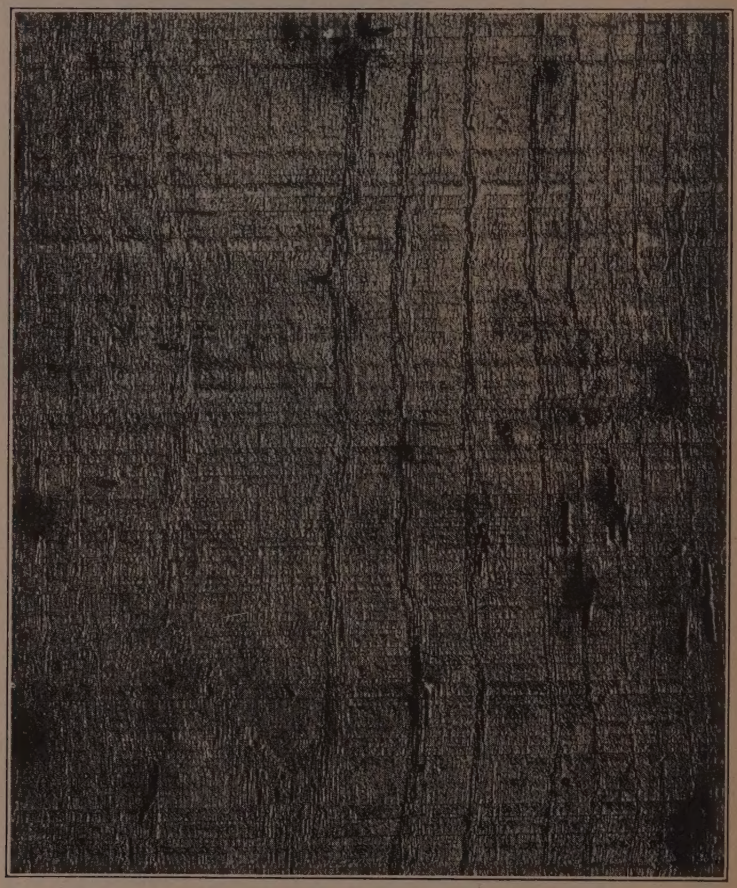

FIG. 9.—Pinholes with short stain streaks made in green ash lumber by *Platypus compositus*

have been made periodically, and often many years before the tree was cut. The dates when the injury was done can be determined by counting the annual rings of tree growth. Usually the wood surrounding pinholes of this type is stained.

PINHOLES IN LIVING TREES CAUSED BY AMBROSIA BEETLES

Pinholes are uniform in size, one-eighth of an inch in diameter or smaller (to one twenty-fifth inch), either darkly stained or un-

stained, or with short streaks in the surrounding wood; these holes run deeply in every direction in an irregular manner through the wood, and it is difficult to determine their extent from the surface. They are termed "pinholes," "shot holes," or "black holes" (*36*). Such holes occur in both the sapwood and heartwood of softwoods and hardwoods, but are more common in the sapwood.

One of the commonest defects (fig. 1) is caused in living trees by an ambrosia beetle,[2] and the holes are known as "black holes," "spot worm," "steamboats," "grease spots" (West Virginia), and "flag worm" (Arkansas). The holes usually occur in the best part of the wood, either one in a place, or two or more in a row. This defect is so prevalent in mature white oak and other oaks that it is often difficult to find a tree the wood of which is entirely free from it; in yellow poplar the defect is not so common. When the defect does occur in whitewood or yellow poplar the accompanying long, black, greenish or bluish streaks give a calico effect, and the wood is called "calico poplar" (fig. 2) (*23*, *27*). The same defect occurs in beech, birch, basswood, maple, and elm in West Virginia, elm and oak in Michigan, oak in Arkansas, and chestnut in Tennessee.

FIG. 10.—Pinholes made by *Xyleborus* sp. in green chestnut board, after piling

Calico poplar and oak might be used, when available in sufficient quantity, as a special grade for interior natural-wood finish, as the effect is pleasing. Thus the apparently limited quantity could be utilized without having its value depreciated much below that of the first and second grades.

This defect causes a serious loss to stave and shingle stock. In Arkansas from 30 to 40 per cent of white oak Bourbon whisky-barrel-stave stock and staves has often been left to rot in the woods on account of injury by the oak timber worms and ambrosia beetles.

[2] *Corthylus columbianus* Hopkins.

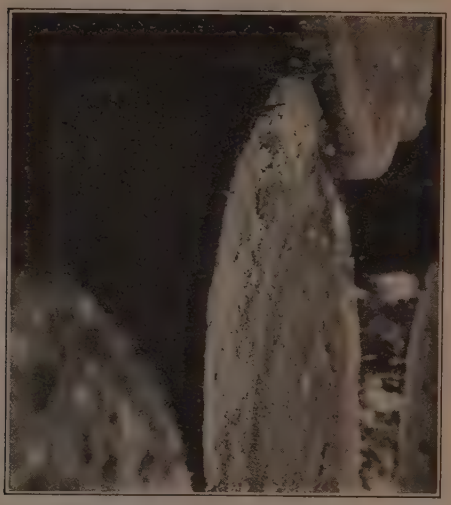

FIG. 11.—Pinholes in the sapwood of high-grade cypress blocks; end view of logs in freight car; wood completely riddled by ambrosia beetles (*Platypus compositus* and *Xyleborus* sp.)

FIG. 12.—Pinholes caused by ambrosia beetles (*Xyleborus* sp.) in mahogany flitches

A loss of $5 to $20 per thousand feet of timber is a conservative estimate. This defect is classed as "wormholes, no living worms or decay," and can not be prevented in the tree, but of course similar defects in the green stock can be prevented by proper handling.

Pinholes one twenty-fifth to one-eighth of an inch in diameter in both heartwood and sapwood of hardwoods and softwoods (figs. 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14) are caused by similar beetles.[3]

FIG. 13.—Pinholes caused by ambrosia beetles (*Xyleborus* sp.) in imported greenheart (*Nectandra rodioei*)

The defects caused by these pinholes and stains (discolored streaks and patches) (figs. 1, 2, 3, 4, 6, 9, and 13) reduce the grade of timber and its full strength, unfitting it for structural timber, wagons, agricultural implements, tight cooperage, and shingles. A 25 per cent loss of elm cooperage stock in logs at the mills in Illinois was due to such defects. In some cases millions of feet of timber have been reduced 10 to 25 per cent or more in value by pinhole defects. In deadened standing cypress in the Gulf States, pinhole injury can be prevented by girdling the trees in March, April, October, and November (*28*), but from August to September is apparently the most effective season.

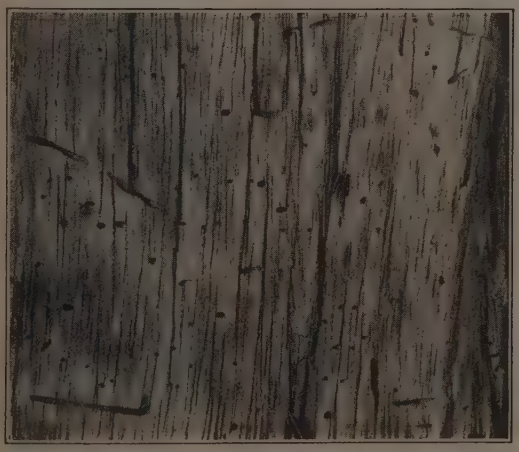

FIG. 14.—Pinhole damage by ambrosia beetles (*Xyleborus grenadensis*) to Hura wood (Rakuda) imported from Central America

[3] Platypus, Monarthrum, Xyleborus.

PINHOLES IN LIVING TREES CAUSED BY TIMBER WORMS

Pinholes or wormholes in the heartwood of chestnut and red oak, one one-hundredth to one-fourth of an inch in diameter, open, clear, not stained, but lined with a substance about the color of the wood, a large number of holes in a given space, are made by timber worms hatching from eggs laid in or near scars. The holes made by the grubs are not of uniform size; they may extend several feet through the wood. (Fig. 15.)

This defect, due to the chestnut timber worm,[4] is one of the most common and serious defects in chestnut timber throughout its range. It is rare to find chestnut trees, logs, or telephone or telegraph poles free from this defect, and practically every tree of merchantable size is more or less affected. There is a very low percentage of "clear" chestnut, the remainder being "wormy" and reduced to the lower grades. This defect is a "sound wormy" injury and can not be prevented. Unfortunately the chestnut is rapidly becoming extinct as a commercial tree, owing to the chestnut blight fungus.

FIG. 15.—Holes caused by the chestnut timber worm (*Melittomma sericeum*), which causes the defect classed in the grade "sound wormy chestnut"

Wormy chestnut and oak wood can be used wherever structural strength is not necessary. They are especially suitable as the base for veneer in manufacturing pianos, caskets, coffins, automobile running boards, and the lower grades of building lumber, because of the comparatively reasonable price at which this grade of lumber can be bought. Much timber that would otherwise be wasted can be thus utilized. There is, however, a limit to the size of the holes admitted.

Similar pinholes or wormholes one one-hundredth to one-eighth of an inch in diameter in oak timber (fig. 16) are caused by the oak timber worm.[5] This defect is especially serious in large mature white oak trees. The holes occur in large numbers in a given space and extend in all directions through the solid heartwood. This insect usually affects the wood of the finest old, mature, or overmature trees, sometimes causing defects which result in the discarding of entire trees for such uses as tight barrel staves. This defect is classified under the term "wormholes, no living worms or decay," and can not be prevented when occurring in living trees, although losses can be lessened by clean forest management; that is, removal

[4] *Melittomma sericeum* Harris. [5] *Eupsalis minuta* Drury.

of old dead and dying snags, stag-headed trees, and trees badly fire-scarred. From 20 to 25 per cent of oak lumber may be wormy from this cause. A loss of 15 to 20 per cent of the product is considered low.

Pinholes or wormholes one-eighth to three-sixteenths of an inch in diameter, few to many grouped in a given space, accompanied by a staining of the wood, or all more or less connected by irregular blackened streaks, in oak, maple, tupelo gum, beech, and other hardwoods, are similar to those caused by the oak timber worm. This defect is caused by tenebrionid timber worms.[6] The insect lays its eggs in the living tree near a scar or wound, and many larvæ working together excavate irregular cavities and longitudinal burrows sometimes a foot in length. This defect is fairly common throughout Pennsylvania, Maryland, and Virginia and is classed as "wormholes, no living worms or decay." Although the losses can be greatly lessened by clean forest management, they are not preventable from the lumberman's standpoint.

FIG. 16.—Pinholes caused by the oak timber worm (*Eupsalis minuta*), which causes the defect classed in the grade "sound wormy oak"

PINHOLE DEFECTS FORMED IN WOOD AFTER THE TREES ARE FELLED; A PREVENTABLE LOSS

Pinholes in felled timber are similar to those caused in living trees by ambrosia beetles and timber worms. Such holes are less than one-eighth of an inch in diameter and open, either darkly stained or unstained, or with dark streaks in the surrounding wood.

PINHOLES IN FELLED TREES CAUSED BY AMBROSIA BEETLES

In sapwood or heartwood of white oak, chestnut, yellow poplar,[7] birch, beech, and sweet gum the pinholes caused by ambrosia beetles are about one-twelfth of an inch in diameter, open, usually isolated, and always accompanied by long, discolored streaks in the surrounding wood. Lumber with such defects is rejected for the higher grades.

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[6] *Strongylium* spp.

[7] The adult of *Corthylus columbianus* Hopkins causes pinholes in hardwoods with which discolored streaks are associated.

In Arkansas a 2 per cent loss of the product of green or newly manufactured white-oak Bourbon whisky-barrel staves occurred at one operation.

Pinholes one twenty-fifth to one-eighth of an inch in diameter occur in the sapwood of both hardwoods and softwoods (figs. 3, 4, 5, 7, 8, 9, 10, 12, 13, 14); in hardwoods usually the wood is not stained; but in freshly cut green hardwoods the wood may be stained. A few to a large number of holes occur in a given space; often every square inch of wood is penetrated. These common pinhole defects in recently felled green logs or bolts (with or without the bark) and closely piled green timber and lumber are caused by ambrosia beetles[8] (figs. 4 and 5). There are two types of galleries made by these beetles—one, a long, winding main gallery and usually no staining of the wood, and the other, a series of short side galleries at right angles to this main gallery (figs. 1 and 6), the gallery usually being accompanied by a staining of the wood. Unlike holes made by the timber worms, which increase with the growth of the worms, these holes are more or less uniform in size.

FIG. 17.—Pinholes in yellow birch caused by the sapwood timber worm (*Hylecoetus lugubris*). (Drake)

PINHOLES IN FELLED TREES CAUSED BY TIMBER WORMS

Pinholes caused by timber worms in the heartwood of chestnut[9] and oak[10] can be recognized as follows: Holes from one one-hundredth to one-fourth of an inch in diameter; open and not stained; a large number to a given space.

Such holes may be a serious defect in square timbers used in structures the woodwork of which is exposed to the weather. Care should be exercised in utilizing wormy oak in structural work where strength is required, or in vehicle, ladder, or implement stock. It should be

[8] *Gnathotrichus* and *Xyloterus*.

[9] The larvae of *Melittomma sericeum* Harris cause wormy chestnut and oak; the eggs are laid under bark.

[10] The larvae of *Eupsalis minuta* Drury cause wormy oak; the eggs are laid under bark.

rejected for barrel staves and heads of tight cooperage, unless the holes are few and can be plugged. Such stock can be used where the holes can be plugged, puttied, and painted over, or as a base for veneer.

Pinholes or wormholes one one-hundredth to three-sixteenths of an inch in diameter in green saw logs with the bark on, of basswood, buckeye, chestnut, black walnut, cottonwood, yellow poplar, and birch (fig. 17), are caused by the sapwood timber worm,[11] which may cause a 5 to 10 per cent loss of a log. This defect is described as "wormholes, no living worms or decay," and can be prevented.

The insect lays its eggs in dying trees and green saw logs which are allowed to lie in the woods with the bark on from April to July, in the States north of the Gulf. The eggs are deposited in crevices in the bark. The beetle will not lay its eggs in barked logs or logs which are floating in log ponds.

In the sapwood or heartwood of oak, maple, tupelo gum, and beech, grouped holes from one-eighth to three-sixteenths of an inch in diameter and all more or less connected by irregular blackened streaks are caused by tenebrionid timber worms.[12]

FIG. 18.—Holes caused by termites (*Coptotermes niger*) in log imported from Honduras; damage to the living tree caused this defect in the board

[11] *Hylecoetus lugubris* Say.
[12] The larvae of *Strongylium* spp. cause wormholes in hardwoods.

Pinholes of these and all other kinds made in timber after felling are preventable by prompt handling and rapid utilization of felled timber. Green logs or bolts, either with or without the bark on, should be placed in the mill pond as soon as possible after being cut, especially during the warm months of spring, summer, or fall, or in damp weather. In the mill pond the logs should be floated in loose booms, so that they can be rolled over and turned to make sure that they are periodically submerged on all sides. The damage can also

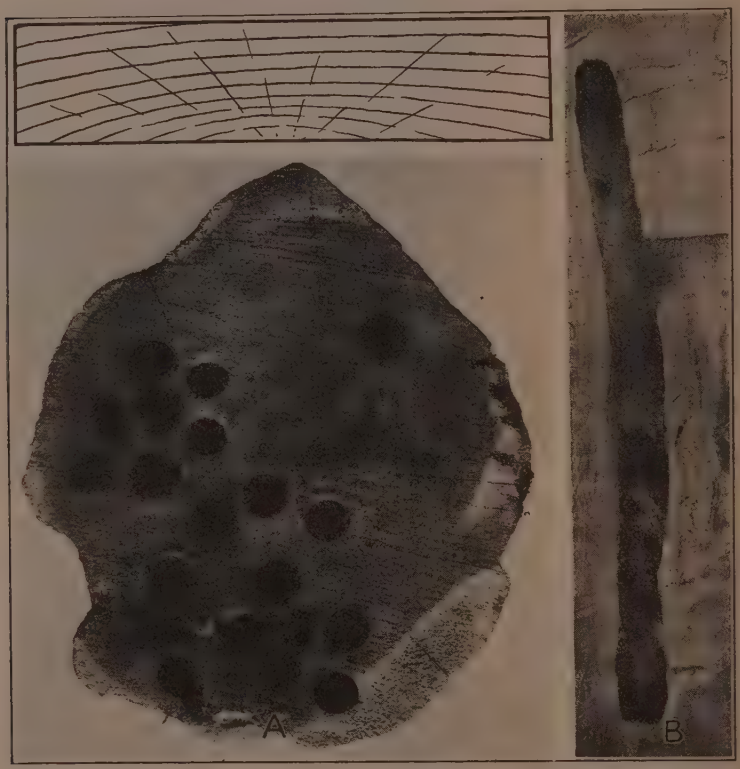

FIG. 19.—Grub holes and burrow caused by carpenter bee (*Xylocopa* sp.) in juniper from Arizona

be prevented by sawing the logs into timber and lumber as soon as possible.

If it is not possible to get the logs into the mill pond, they can be sun cured or dried rapidly (*10*, *11*, *15*, *16*, *17*, *18*, *19*, *20*) to bring about conditions unfavorable to insect attack, which is accomplished by peeling them and placing them on "browse" (limbs) on knolls in open places in the sun. Other preventive measures consist of girdling before cutting, peeling, cutting, and leaving the tops on for a time before logging or after cutting. Barking the logs will prevent

FIG. 20.—A, enlarged holes made by carpenter ants (*Camponotus* sp.) in red cedar in Washington; B, redwood damaged by carpenter ants in California

FIG. 21.—Work of a horntail (*Urocerus albicornis*) in a decaying softwood log

damage by timber worms, as will also coating or spraying with preservatives.

Repellent, poisonous, or stickly chemical sprays, to prevent attack by ambrosia beetles on more valuable species and products, can be used where the bark is on the logs and the wood will not be discolored (*12*). The preservative coating known as hardened gloss oil has the advantage of preventing checking.

Green lumber should be kiln-dried (*49*); or, where this is not practicable, piled on stickers (*1*), to insure rapid air seasoning. Air

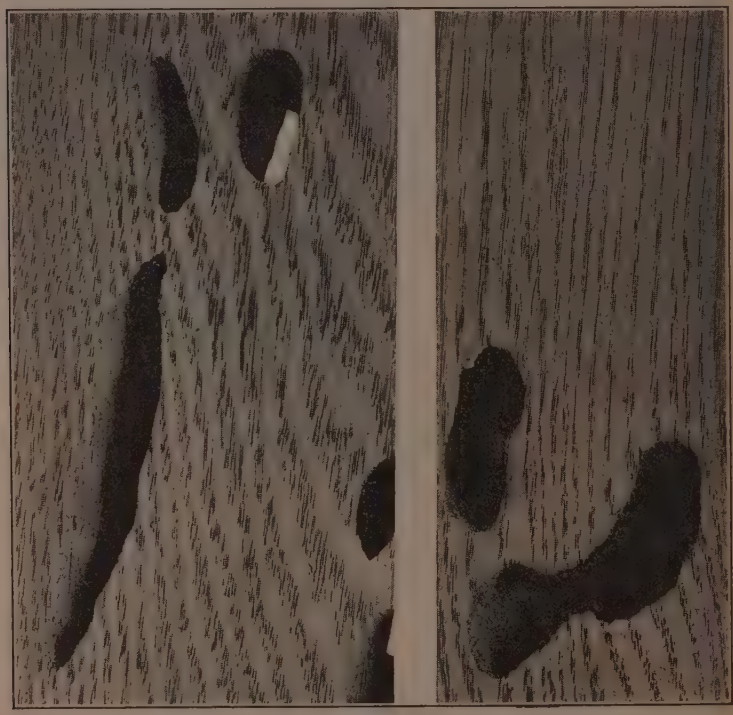

FIG. 22.—Grub holes made by the oak carpenter worm (*Prionoxystus robiniae*)

seasoning of green freshly sawn timber or lumber by open or loose piling is a preventive. In cribbing or proper piling of green sawn stock to facilitate rapid drying, care should be taken to insure against severe checking from too-rapid drying. Heavy dimension timber should be stacked in loose piles. If it were possible to kiln-dry the material, insect damage, of course, would be prevented.

In the case of damage to stave stock, by special methods of sawing the waste can be reduced to a minimum and a very considerable saving of material effected. Where the holes are not too numerous, they can be plugged with wooden pins and the wood used for casks.

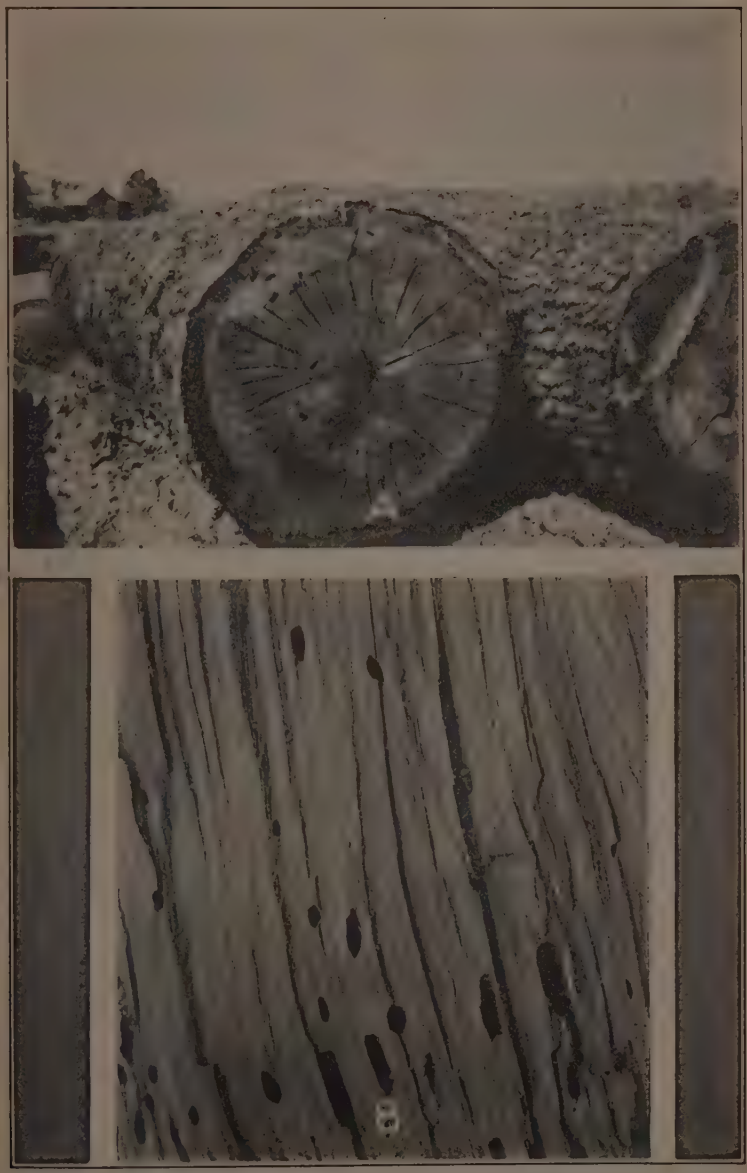

FIG. 23.—A, grub holes in overcup oak, made by the Parandra borer (*Parandra brunnea*) near Vicksburg, Miss.; B, grub holes in soft maple made by the Parandra borer in Maryland

The defect does not deteriorate furniture and inside-finish stock. This defect is considered under "wormholes, no living worms or decay," and in the interest of conservation and closer utilization, timber with these defects should be used.

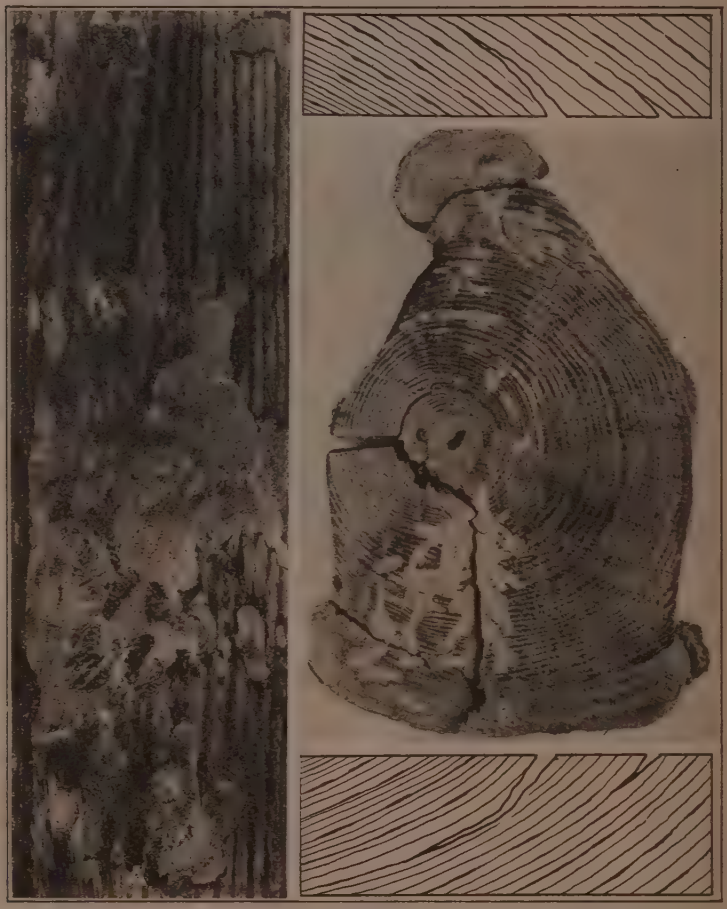

FIG. 24.—A, grub holes made by a flat-headed borer (*Buprestis apricans*) in the pitchy "fatwood" of the basal log of long-leaf pine; B, the same in a turpentined tree

PINHOLE INJURY TO IMPORTED LOGS

Large quantities of tropical woods in the rough, round, or squared log are yearly shipped into the United States from Central and South America, the West Indies, Africa, and the Philippines. (Figs. 12, 13, and 14.) Almost invariably such timber, if received within a year after it is cut, contains many species of pinhole-boring beetles, but these never live over the winter, except perhaps in the Gulf States.

Under present methods of lumbering, such imported logs usually are infested by pinhole-boring beetles of many species, which attack the logs after they are cut, and continue to live in them for several months and in some cases a year or more. If such logs are shipped into another country with a similar climate, the insects may survive and attack logs of native timber; if, on the other hand, logs are exported to a much colder or hotter country, the insects will rarely, if ever, become established in the country of import.

There is, therefore, some danger of introducing destructive species through the commercial interchange of timber in the form of logs.

FIG. 25.—Wormholes caused by "sawyers" (*Monochamus* spp.) in pine. A and B, wormholes in southern yellow pine; C, wormholes in white pine

For example, many insect species are widely distributed over tropical America that do not occur in tropical Africa, Asia, Australasia, and the Pacific islands. Tropical Australia, the Philippine Islands, and tropical Japan doubtless have a considerable number of the same species of pinhole borers. One country may have a few that do not occur in the others.

DEFECTS CLASSED AS GRUB HOLES OR WORMHOLES

Grub holes are medium to large, circular, oval, or irregular holes from three-eighths to 1 inch in diameter, in both sapwood and heart-

wood of all kinds of timber. They may either be stained black inside or be of the same color as the surrounding wood, and they may be free and open or filled with tightly-lodged boring dust, depending on the kind of insect making them. This boring dust does not fall out when the wood is jarred. Grub holes are made in the living tree, in the saw log, or in piled green lumber. In nearly all cases the injury is caused by the young borers, sawyers, or grubs, but occasionally also by adult termites or white ants (fig. 18), adult

FIG. 26.—Wormhole defects in cedar, caused by the round-headed borer *Callidium antennatum*

carpenter bees[13] (fig. 19), or carpenter ants[14] (fig. 20), or by the larvae of horntails[15] (fig. 21). Usually this type of injury is considered as "wormholes, no living worms or decay," especially if the holes are stained black, and no further damage will result, except in rare cases.

Grub holes constitute a standard defect and are also included under "equivalent defects." They are often of considerable size

[13] *Xylocopa* spp.
[14] *Camponotus* spp.
[15] *Tremex columba* L., or *Sirex* spp.; they usually damage only dead wood or trees or logs that have been left in the woods too long.

and consequently reduce the structural strength of the wood, especially when cut into smaller dimensions; therefore timber having such borer holes should be used in as large dimensions as possible.

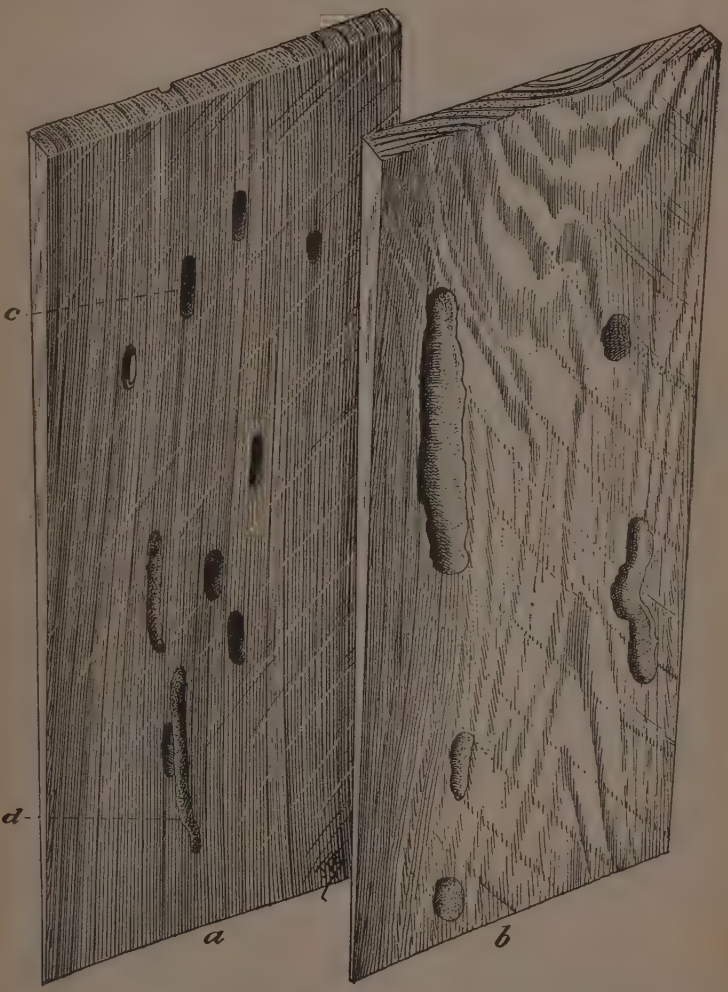

FIG. 27.—Western red cedar shingles badly damaged by grub holes and burrows of flat-headed borers (*Trachykele blondeli*). (7). *a*, Quarter-sawn shingle showing both cross and longitudinal sections, *c*, *d*, of the larval mines; *b*, bastard-sawn shingle showing larval mines

GRUB-HOLE INJURY TO LIVING TREES; A NONPREVENTABLE LOSS

Grub-hole defects in living trees can not be prevented by lumbermen, since often these defects occurred many years before the tree was cut. Sometimes the insect holes are partially healed over by

new growth of the tree, or they may have been enlarged by carpenter ants. This type of injury can be recognized as follows:

(1) In the sapwood and heartwood of hardwoods very large circular holes, one-half to 1 inch in diameter, are open and but slightly stained and are usually lined with a silky yellowish-brown web.[16] (Fig. 22.)

(2) In sapwood or heartwood of hardwood trees the holes are darkly stained and are open, containing little or no sawdust or frass.[17]

FIG. 28.—Powder-posted white ash shipbuilding lumber showing larval burrows and exit holes of adults of *Lyctus planicollis*; board from a closely piled stack of lumber throughout which larvae had burrowed

(3) In the heartwood of butt logs of gum and a few other hardwoods, unstained holes contain mined granular and fibrous frass[18] (fig. 23).

(4) In the heartwood of butt logs of softwoods, chiefly pine, very irregular holes are narrowly oval, without stain, but surrounded by much pitchy "lightwood," or "fatwood," and are very tightly packed with fine granular frass[19] (fig. 24) (7).

(5) Pinholes or wormholes in softwood logs and lumber in the Northern States are caused by a melandryid timber worm.[20] These larvae gain entrance to the living sapwood through scars or blazes and also attack recently felled timber. The holes are filled with fine sawdust.

GRUB-HOLE INJURY TO GREEN SAW LOGS AND LUMBER; A PREVENTABLE LOSS

All types of borer holes other than those mentioned above are made after the trees have been felled, and are preventable by proper methods of handling the logs. These borer holes occur in the sap-

[16] This injury is found principally in oak, chestnut, locust, and cherry and is caused by the carpenter worm, *Prionoxystus robiniae* Peck.

[17] These holes are found principally in oaks and are caused by the round-headed borers (Cerambycidae) *Goes* spp. and *Romaleum* sp.; in hickory, they are caused by *Goes* sp.; in hickory in the South, small darkly stained holes are caused by a wood-boring caterpillar, *Cossula magnifica* Bailey; and in hard maple they are caused by the maple-tree borer, *Glycobius speciosus* Say.

[18] This injury is caused by *Parandra brunnea* Fab.

[19] This injury is caused by *Buprestis apricans* Hbst. and occurs especially in fire-scarred long-leaf pines and trees boxed for turpentine. This borer causes an excess of pitchy wood near the injury. The injury often amounts to the reduction of 5 to 10 per cent of the lumber to lower grades and the wind-throw of much second growth on turpentine operations.

[20] *Serropalpus barbatus* Schall.

wood of hardwoods or softwoods as unstained irregular holes from one-fourth to 1 inch in diameter, which may be open, loosely or tightly filled with powder, with granular or fibrous frass, or with pellets.[21]

These and similar types of borer injury can be prevented by prompt handling of the logs after they are felled. Logs, bolts, and sawn or squared timbers should never be allowed to lie where cut in the woods, after the 1st of February in the Gulf States, or after the 1st of April farther north. Other preventive measures include: Rapid utilization; submergence of logs in water, where they will not be attacked, and working them up as soon as removed from the water; sun-curing, with or without the bark on (care should be taken to provide against excessive checking); and removal of bark strips from freshly sawn material. The damage can often be prevented by peeling the bark (both outer and inner) from the logs or bolts, timbers, or edges of lumber, as the bark offers a favorable place under which the insects can lay eggs. Both the outer and inner bark of sawn timber should always be carefully removed and the timbers placed where they will season rapidly (*1*).

FIG. 29.—Powder-posted sapwood oak veneer laid on a core of chestnut (door stock); work of *Lyctus planicollis*. Note that the heartwood oak and the chestnut have not been attacked

DEFECTS CLASSED AS POWDER POST

Powder post is indicated by holes from one-sixteenth to one-fourth of an inch in diameter, in the surface of the wood, in the sapwood and

[21] The principal injury of this character found in pines, spruces, and firs is caused by the pine sawyers, *Monochamus* spp. (fig. 25) (*50*); the loss due to pine sawyers in green logs and storm-felled timber is often as high as 35 per cent. In ash the defects are caused by the banded and red-headed ash borers, *Neoclytus capraea* Say and *erythrocephalus* Fabricius; in hickory by the banded hickory borer, *Cyllene pictus* Drury, and the red-headed ash borer; in locust by the locust borer, *Cyllene robiniae* Forster: in cedar by the round-headed borer *Callidium antennatum* Newm. (fig. 26); in cypress, western redwoods, and cedars by flat-headed borers, *Trachykele* spp. Burrows made by Trachykele are tightly packed with pellets of excrement, and shingle stock is full of holes (fig. 27) (*7*).

heartwood of both hardwoods and softwoods, from which the powder will fall when moved or jarred.[22] The interior is honeycombed by irregular burrows made by the larvae and when badly damaged is converted into a mass of closely packed material, which readily crumbles into fine flourlike powder or coarser pellets of excreted wood. This is held together by an outer thin shell and intervening fibers of sound wood. These defects will be discussed in the order of the size of the holes caused by the various types of insects. All powder-post damage can be prevented.

FIG. 30.—Powder-post defect in pine made by *Xyletinus peltatus*

POWDER POST CAUSED BY LYCTUS BEETLES

The injury caused by Lyctus beetles is confined to the white-wood or sapwood of hardwoods (*34*). It consists of small holes one-sixteenth to one-twelfth of an inch in diameter, with irregular burrows filled with flourlike powder. Air-dry or kiln-dry sapwood material, and sapwood which has been stored or piled in one place for two, three, or more years, especially second-growth ash, hickory, and oak, are principally affected; but other hardwoods, such as walnut, maple, persimmon, cherry, elm, poplar, and sycamore, are also damaged.

Seasoned shipbuilding and airplane lumber and gunstock blanks, stored in large quantities, and finished stores, such as wheelbarrows, tent poles, oars, airplane parts, shovel and pick handles, and many other hardwood articles used in the military services are subject to serious damage by powder-post beetles. (Fig. 28.)

Hickory, ash, and oak furniture, interior woodwork of buildings (fig. 29), and the woodwork of farming machinery and implement handles; ladder stock, such as rungs; vehicle stock, such as hubs, spokes, felloes, rims, singletrees, poles, and shafts; and cooperage stock (barrel-stave bolts) are also injured.

[22] Insects which have this peculiar habit of reducing wood fiber to a powderlike condition belong chiefly to the families Lyctidae, Ptinidae, Anobiidae, Bostrichidae, and Cerambycidae. By far the larger part of the injury is caused by species of the genera Lyctus and Neoclytus.

The loss to seasoned hardwood products ranges from 10 to 50 per cent, sometimes representing a loss of thousands of dollars to a single manufacturer or dealer who neglects to adopt the proper preventive measures. The affected articles are not only reduced in value, but

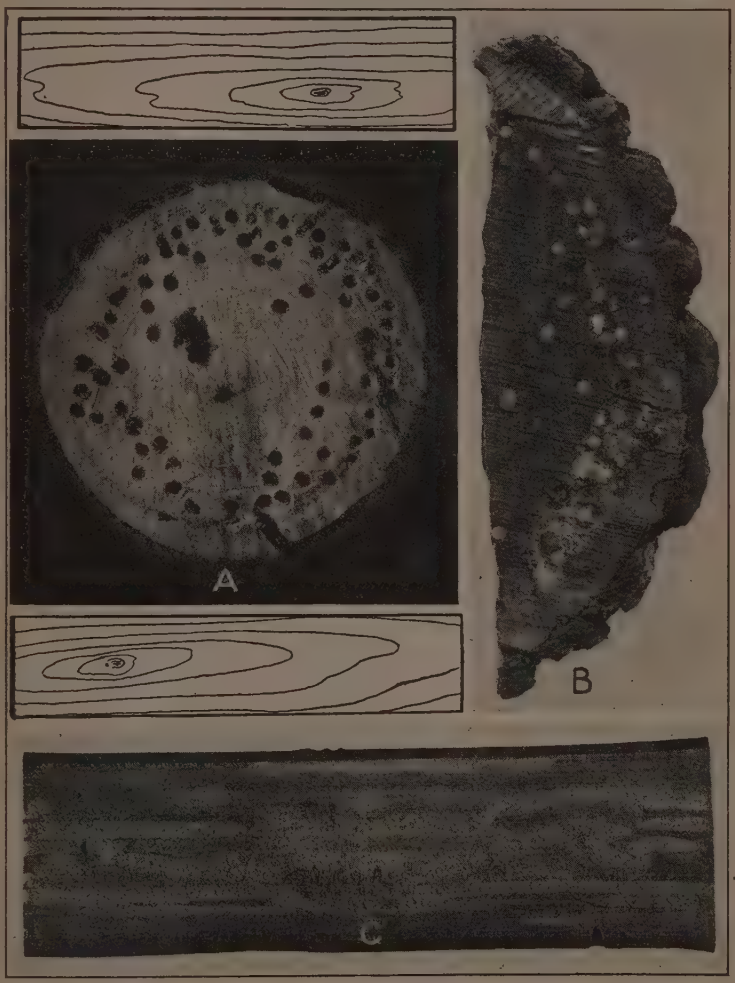

FIG. 31.—Powder-posted seasoned hickory stock in the rough damaged by *Xylobiops basilare*. A, end of bolt; B, end of section of bolt; C, planed section of damaged bolt

frequently are rendered worthless for the purposes for which they are intended. In the aggregate the direct financial loss that has been caused by these beetles in this country has amounted to hundreds of thousands of dollars. The loss increases with the length of time the infested stock is held in storage; the wood may be reinfested by many

generations over a period of 20 years or more. In certain cases powder-post injury may be a menace to human life, as in the weakened woodwork of buildings, vehicle stock, or ladders.

Losses due to Lyctus beetles can be prevented by proper methods of classification and piling of stock by kinds; by keeping heartwood

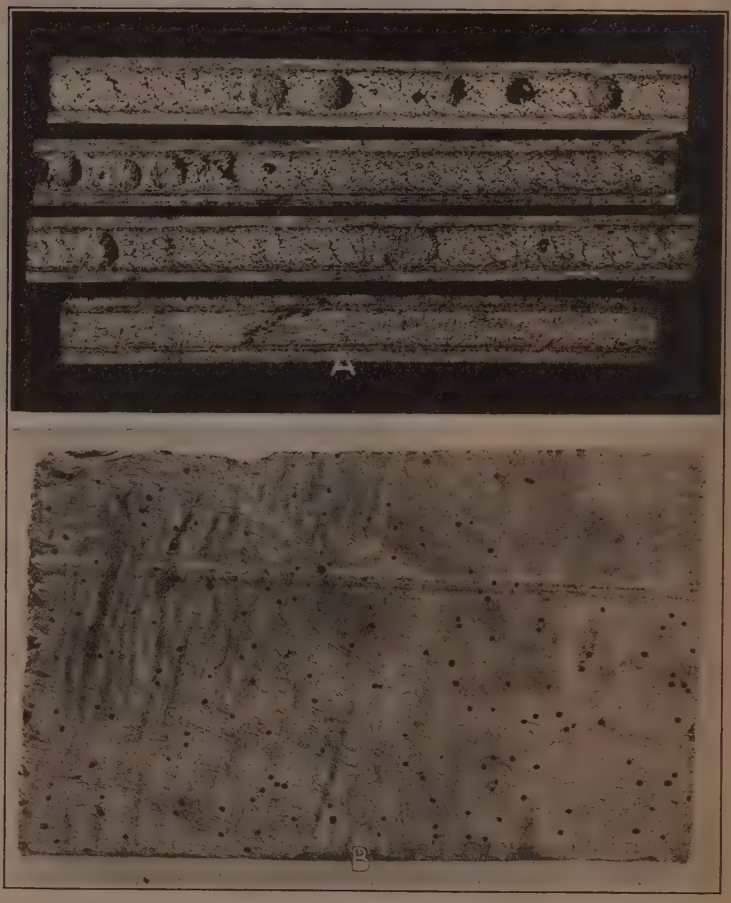

FIG. 32.—A, Duali plywood, imported from the Philippine Islands, powder-posted by *Bostrychopsis parallela*; B, bostrichid powder-post injury to myrtle in Oregon

and sapwood stock separate; by periodical inspection, utilizing the older stock first (*34*); and by using only heartwood piling sticks; or by submergence in water for four months, which renders the wood immune from attack, even after removal from the water.

In the case of finished wood products, it may often be practicable to treat the wood with substances to prevent attack. Creosotes are

effective preventives, but they stain the wood; hence, where they can not be used, in the light of the discovery of the place and manner of the laying of the eggs in the pores of the wood, any substances that will close the pores will prevent oviposition in wood not previously infested. In wood from which beetles have emerged, however, eggs might be laid within the exit holes. Paraffin wax, varnish, linseed oil, or other fillers effectively close the pores of wood. A certain varnish known as hardened gloss oil is commonly used. Wood that has been seasoned less than 8 to 10 months will not be attacked by Lyctus beetles; therefore, in applying chemical preventives, only sapwood that has been seasoned for 8 to 10 months and longer need be treated. The seasonal history of these beetles indicates that preventives should be applied before March 1.

FIG. 33.—Holes made by the banded ash borer (*Neoclytus capraea*), one of the powder-post beetles

FIG. 34.—Powder-posted ash shipbuilding lumber, showing coarse powdery frass in the burrows made by *Neoclytus capraea*

The great and recurring expense of treating infested wood can be avoided by prevention of attack by proper methods of management. Since only the sapwood or whitewood is attacked by Lyctus powder-post beetles, it is recommended that more heartwood be used to replace sapwood. Although the demand of the trade is for whitewood handles, etc., the prejudice against heartwood is not warranted

and should be overcome by educational propaganda. Weight for weight, red or heartwood hickory is as strong as white or sapwood. Closer utilization can be effected by larger use of heartwood. Some manufacturers paint their stock, to overcome this trade prejudice.

Effective remedies include kiln-drying at high temperatures (180° F. and over); steaming at 130° F. (this will not insure against future attack) (*46*, *47*); and treatment with orthodichlorobenzene or a mixture of kerosene and coal-tar creosote, after which the material should be kept in quarantine a sufficient length of time to determine whether a second treatment is required.

FIG. 35.—Powder-posted southern yellow pine boards damaged by *Hylotrupes bajulus*

Partially damaged material which is too valuable to be destroyed should be salvaged, when practicable, by trimming off and burning the sap edges and other damaged and infested parts.

POWDER POST CAUSED BY PTINIDAE AND ANOBIDAE

This damage consists of small holes one-sixteenth to one-eighth of an inch in diameter and irregular burrows in the wood of both softwoods and hardwoods (fig. 30). The damage is similar to that caused by Lyctus beetles, except that softwoods are also attacked and the defect occurs [23] in the heartwood. Most injury by Ptinidae is caused to seasoned wood, or logs that have been left lying in the woods too long.

POWDER POST CAUSED BY BOSTRICHIDAE

This damage consists of circular holes one-eighth to three-eighths of an inch in diameter and irregular longitudinal burrows filled with frass, or with coarser dust in the sapwood and heartwood of hardwoods, which does not fall out so readily. (Figs. 31 and 32.)

These insects [24] attack freshly felled logs with the bark on. The eggs are laid within the log near holes made by the adult beetles.

Submerging the logs in the mill pond and prompt utilization will prevent much loss. In the case of vehicle, handle, and similar

[23] This defect is caused by *Xyletinus peltatus* Harris, which attacks both hardwoods and softwoods.

[24] Bostrichidae: Scobicia, Xylobiops, etc.

stock, all the bark and edgings should be removed; treatment with shellac or wax will also prevent the adult beetles from boring into the wood to lay eggs.

POWDER POST CAUSED BY ROUND-HEADED BORERS (CERAMBYCIDAE)

Holes about one-eighth of an inch in diameter, tightly packed with finer frass, in the sapwood or heartwood of oak and hickory, are made by the flat powder-post beetle.[25] It attacks both freshly cut and seasoned timbers and continues to work for a number of years. Damage can be prevented by prompt handling of the logs, removal of the bark, and disposal of infested stock.

FIG. 36.—Ring distortions in balsam caused by the spruce bud worm. Base of tree attacked in 1911 showed accelerated growth for two years, followed by retardation and incomplete ring in 1918 (X), and rapid recovery later. (*48*)

Oval holes about one-fourth of an inch in diameter or irregular burrows tightly packed with coarse, powdery frass, in the heartwood and sapwood of ash, are caused by a round-headed borer.[26] (Figs. 33 and 34.) This insect attacks only freshly cut timbers, but when infested logs are stored the borers continue to work for several years (*51*).

Prompt utilization, submerging the logs in the mill pond, rapid seasoning, or removal of the bark will prevent this defect. Timber should be felled in the late fall or winter, so that the bark may dry somewhat and be less attractive to the beetles when they are flying and depositing their eggs early in the spring. In the Gulf States logs should not be allowed to lie in the woods at any time for more than two to three weeks, or after the 1st of April farther north, nor should they be

[25] *Smodicum cucujiforme* Say. [26] *Neoclytus capraea* Say.

stored in closely packed piles for long periods. After the 1st of February logs should be cut up into sizes as small as commercialy practicable and seasoned as promptly as possible; or sun-cured; or placed in the mill pond. Narrow strips of bark left on the edges of boards and planks or timber cut from green logs in February and March serve to attract the insects to such places to lay their eggs; therefore the logs should be trimmed off and the trimmings burned.

Irregular oval holes from one-fourth to one-half inch in diameter, filled with a mixture of coarse granular and fine powdery frass, found in softwoods, are caused by the "old house borer."[27] (Fig. 35.)

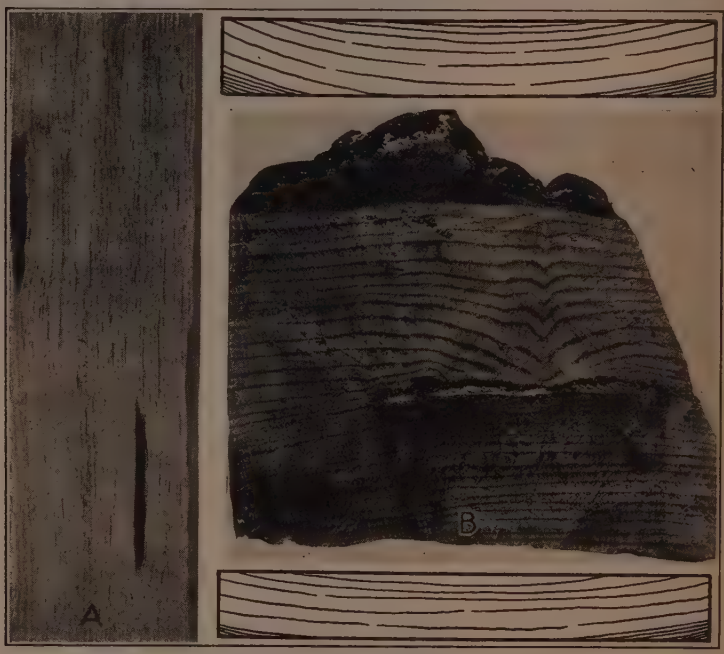

FIG. 37.—Pitch pockets in western yellow pine, caused by unsuccessful attack, years ago, by the Black Hills beetle (*Dendroctonus ponderosae*). A, pitch pockets in sawn board; B, end of log showing pitch pockets

It attacks only well-seasoned wood which has been stored for more than a year. This borer continues to work for years, until the wood is thoroughly perforated.

All bark edges should be removed from lumber and timber; the stock should be inspected frequently for evidences of falling dust, which indicates the presence of these borers, and all such wood should be promptly burned; or the stock may be dipped in orthodichlorobenzene, if only slightly injured.

POWDER POST CAUSED BY FLAT-HEADED BORERS (BUPRESTIDAE)

In bald cypress in the Eastern States and in western redwoods and cedars, powder-post injury is caused by flat-headed borers.[28]

[27] *Hylotrupes bajulus* L.

[28] *Trachykele* spp.

The burrows are tightly packed with pellets of excrement, and shingle stock is full of holes. (Fig. 27.)

The injury occurs in living, dying, or dead trees, and consists of a flattened, oval, gradually enlarging, more or less tortuously winding mine or wormhole, which, when completed, widens out into an elongate-oval pupal cell. This cell connects with the outer surface by a short, oval exit hole. The mine has its surface marked by fine transverse, crescentic lines, and is usually tightly packed with sawdustlike borings and pellets of woody excrement.

To prevent such injury, the forest should be kept clear of dead and dying trees and of felled trees which afford ideal breeding spots. Such trees might be used for fuel, or they could be piled with the limbs and tops and burned. If trees must be deadened in the lumbering operations, the "deadening" should be done at a time of the year when the sap is not actively flowing. October, November, and December would probably be the best months for this. If the timber must be felled and left in the woods for a time, the felling should be done during the same months, and the logs should be barked and left so that they will dry quickly and thus become distasteful to these borers.

FIG. 38.—Longitudinal section of yellow pine sapling, showing damage to wood from attack of *Pinipestis zimmermanni*. (5)

If the timber is found to be newly infested while standing, or on felling, the most practical remedy is to cut it into logs at once and place the logs in a pond or stream so that the larvae will be destroyed and further damage prevented. If the damage has been done before the lumberman has noticed the injury, which is usually the case, much loss can often be prevented by utilizing the damaged stock to the best advantage. It may be used for poles, posts, planking, sills, small construction timbers, or where the wormholes are not particularly detrimental; it should not be used for cooperage, shipbuilding, shingles, doors, finishing, cabinetmaking, or furniture, in which clear stock is desired; otherwise the loss is apt to be severe, both because of the poor quality of the product and because of the extra labor necessary to produce it (7).

OTHER TYPES OF DEFECTS

Other common defects—ring distortions, pitch pockets, gum spots, black check, staining, and pith flecks—are often caused by insects or associated with insect attack. Such defects, however, are not always necessarily caused by insects.

FIG. 29.—A and B, two views showing small "pitch pocket" or "bird's eye," caused by larva of a fly in western yellow pine

DEFECTS CLASSED AS RING DISTORTIONS

Characteristic distortions and abnormalities in the annual rings of trees result from defoliation by leaf-feeding insects, as well as from other causes, as pointed out by Hartig, Harper, and Craighead (*48*). Destruction of the leaves at certain periods causes a reduction in the normal amount of food manufactured by the tree, with consequent loss in the amount of wood laid on and the formation of incomplete annual layers or double rings (false rings). Many species of trees are subject to defoliation, though little is known of the resulting effects except in a few cases.

Larch, fir, spruce, jack pine, lodgepole pine, western yellow and white pines, hemlock, oak, hickory, catalpa, birch, and cherry are some of the trees subject to frequent or periodic defoliation.

RING DISTORTIONS CAUSED BY DEFOLIATION BY THE BUD WORM

Defoliation by the bud worm [29] on spruce and fir produces the first year a decided decrease in wood on the upper stem, while an abnormally larger ring is laid on at the base. In subsequent years a gradual reduction occurs, the narrowest ring being laid on some four or five years later throughout the tree. Gradual increase then

[29] *Cacoecia* (*Harmologa*) *fumiferana* Clemens.

follows in recovering trees. In fir trees one, two, or three rings may fail to form completely around the stem, particularly at the base, and are represented only by partial arcs (fig. 36) (*48*).

Rings of traumatic resin ducts are frequently deposited in the terminal portions of defoliated fir trees during the first to third years of feeding.

Complete defoliation of certain hardwoods in the early spring produces a double ring the same year. These defects result in a great loss of increment, increasing the rotation from 3 to 10 years, and cause confusion in growth studies based on the annual rings.

Similar distortions of rings are found in Douglas fir, due to defoliation by the spruce bud worm, and in western fir, spruce, yellow pine, and particularly lodgepole pine, due to defoliation by the needle miner.[30]

Such losses and defects can be prevented only by the prevention of defoliation, a problem of forest management.

FIG. 40.—Gum spot in Douglas fir, caused by a flat-headed borer (*Melanophila drummondi*)

DEFECTS CLASSED AS PITCH POCKETS AND PITCHY TIMBER

Pitch pockets are openings between the grain of the wood which contain more or less pitch or bark. They are graded as small, standard, and large pitch pockets. These pockets range from one-eighth inch to 2 inches in width and from 3 to 12 inches in length. Sometimes, instead of pockets, there are merely pitch streaks. These defects may be caused by insects as well as other agents.

The pockets are small, usually about one-half to 1 inch in length, and about one-half inch in width, full of pitch; in pine, they are parallel to the grain. Sometimes they are as large as 2 inches in diameter and contain a large quantity of pitch. This injury may be caused by unsuccessful attacks of bark beetles [31] which have failed to kill the tree and have been drowned out by the flow of pitch. (Fig. 37.) It is a sound defect which can be prevented only by controlling the bark beetles that attack the living trees.

Excessive pitchy streaks in yellow and other pine lumber are sometimes caused by the larvae of a moth [32] working in the cambium (fig. 38), especially in mature trees.

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[30] *Recurvaria milleri* Busck.

[31] *Dendroctonus* spp. The term "pitch pocket" is here used to define what is apparently the tree's further means of defense from attack by bark beetles, after the pitch running out of the entrance hole, forming a pitch tube, has failed to drown out the beetles.

[32] *Pinipestis zimmermanni* Grote, the Zimmerman pine moth.

The wood of trees that have been infested by larvae of the moth is invariably so permeated with pitch that the lumber cut from such logs is either materially reduced in value or is rendered wholly unfit for commercial use. This moth is especially abundant; in southeastern Montana a large percentage of the trees are pitch-soaked. For this reason the lumber is utilized only as rough lumber for sheds and similar structures where shrinkage can be discounted (*5*).

Serious damage by this moth can be lessened by clean forest management.

"Pitch seams," "gum check," or whatever these defects may be termed locally, have always been recognized as a serious depreciating factor in the utilization of Douglas fir (*4*).

FIG. 41.—Black check in western hemlock, radial section. (*6*)

The loss is occasioned by the work of the Douglas fir "pitch moth,"[33] which causes the difference in price between absolutely clear lumber and the lower grades or dimension stuff. These insects work in the portions of the trunks of living trees which later clear themselves of branches; hence only those logs are affected which, were it not for previous infestation by the moths, would yield the better grades of lumber.

Sawyers of Douglas fir estimate a general loss in the entire Douglas fir product of between 7.5 and 15 per cent due to this defect of pitch seams in the logs used (*4*). The depreciation is lowest in the Rocky Mountain region and heaviest toward the Pacific coast. Such pitch pockets are not always caused by insects.

Another pitch moth, the Sequoia pitch moth,[34] greatly retards the growth of lodgepole pine in western Montana (*3*).

Under present forestry conditions in this country it is impracticable to control these insects over large areas.

Similar defects due to the working of the larvae of moths and flies[35] (fig. 39) in pitch near insect wounds or other wounds, occur in all sections of the country.

DEFECTS CLASSED AS GUM SPOTS OR STREAKS

"Gum spots" in western hemlock[36] and Douglas fir[37] are caused by insect attack.

Gum spots entail practically no loss to mills, nevertheless they cause losses to the builder and consumer. Gum-spot defects are also due to causes other than insects.

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[33] *Sesia novaroensis* Hy. Edw.
[34] *Vespamima sequoia* Hy. Edw.
[35] *Cheiloseia* spp.
[36] *Melanophila drummondi* Kirby causes this defect in both hemlock and Douglas fir (fig. 40).
[37] The pitch moth (*Pinipestis zimmermanni* Grote) is responsible for not more than 10 per cent, *Dendroctonus pseudotsugae* Hopkins for not less than 70 per cent, and all other causes for about 20 per cent of the damage.

DEFECTS CLASSED AS BLACK CHECK

"Black check" is the lumberman's name for a common defect consisting of a dark stain in the heartwood and sapwood, surrounded by thickened, curled, or abnormal layers of wood (fig. 41) (*6*). It should not be confused with stains associated in the wood with other boring insects (as ambrosia beetles), where the wood is rarely distorted. Although also caused by other agents, it particularly applies to the defect in western softwoods (hemlock, fir, spruce, and yellow pine) produced by the maggots of several small flies [38] or moths,[39] but the term is also used for a somewhat similar defect in oaks produced by the larvae of large beetles.[40] (Figs. 42 and 43.)

FIG. 42.—Pile of logs with grub holes made by round-headed borer (*Romaleum rufulum*). This defect is considered as "wormholes, no living worms or decay"

These defects are caused by the insects injuring the growing tissue of the tree and killing a small area of the outer layers of wood. The subsequent growth of the tree finally heals over this injury, but many annual layers are stained and distorted. The original small pocket or cavity where the insect was working remains, and in coniferous trees it fills up with pitch.

Western hemlock contains more of this injury than any other softwood. In quarter-sawn (vertical-grain) wood the checks appear as small seams one-half to 1 inch long, with one side curly, while in bastard-sawn (flat-grain) boards they appear as oval or rounded spots from one-half to 1 inch in diameter. The defects in other conifers are similar but not so numerous.

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[38] *Cheilosia* spp. [39] Parharmonia. [40] *Romalcum* sp. and *Goes* sp.

In oak the black checks are larger, often 6 inches long over an area of several square inches. In quarter-sawn boards they appear as dark distorted or curly wood and run through many layers of wood, while in bastard-sawn boards they form black scars several inches long by 1 or 2 wide. In the Ozark Mountains of Arkansas this is a very common defect.

Timber from softwoods or hardwoods is not seriously reduced in strength by such defects, but the wood is lowered in grade and rendered useless for finishing, turning, staves, and woodenware. It can, however, be used for structural material or for purposes for which the marred appearance will not be detrimental. Since black check is always the result of injury to the living tree, it is not preventable, from the lumberman's standpoint.

FIG. 43.—Black check in oak, caused by round-headed borer (*Goes* sp.) in the living tree. The wound has healed over

DEFECTS CLASSED AS BLUING OR STAINING

Bluish-black streaks or stains in the sapwood of pine, especially in southern yellow, western yellow, and sugar pines, as well as in certain hardwoods, such as red gum or sap gum, are classed as bluing. This defect occurs either in the standing tree or in recently cut green logs or green lumber and is caused by fungi developing from spores which are no doubt carried by insects. In pines the bluing directly follows infestation by tree-killing bark beetles [41] in the standing trees (fig. 44) (*29*). This defect can be prevented only by the control of tree-killing bark beetles. Similar staining defects are caused by many ambrosia beetles [42] in both the living trees and green saw logs and green, freshly sawn lumber. (Figs. 4, 9, and 13.) This staining can be prevented in green saw logs by prompt utilization of the green logs; by placing them in the mill pond soon after cutting; or by sun-curing. When the lumber is sawn it should be either kiln-dried or air-seasoned rapidly. Bluing is not always dependent on bark beetles (*42*).

[41] *Dendroctonus* spp. [42] Gnathotrichus, Xyleborus, Platypus, etc.

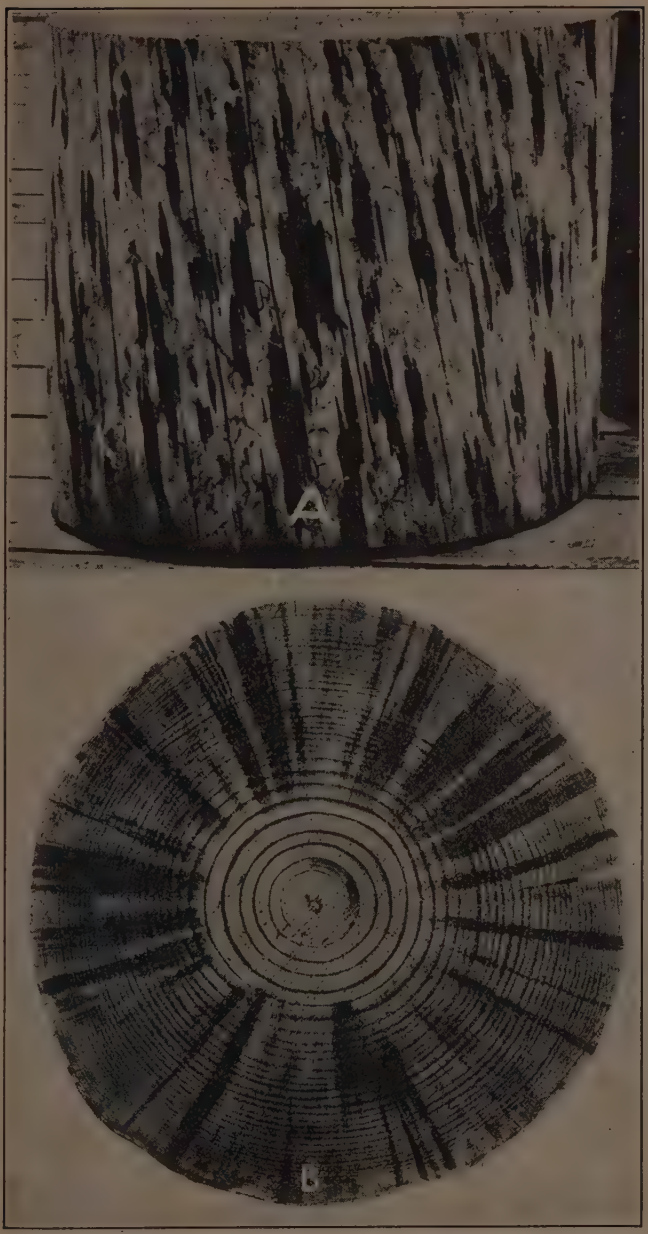

FIG. 44.—Section of short-leaf pine, showing "blue stain" of sapwood after attack by the southern pine beetle (*Dendroctonus frontalis*). A, side view; B, cross section showing stain extending to the heartwood. Serious bluing in the log sometimes appears to take place without the aid of insects

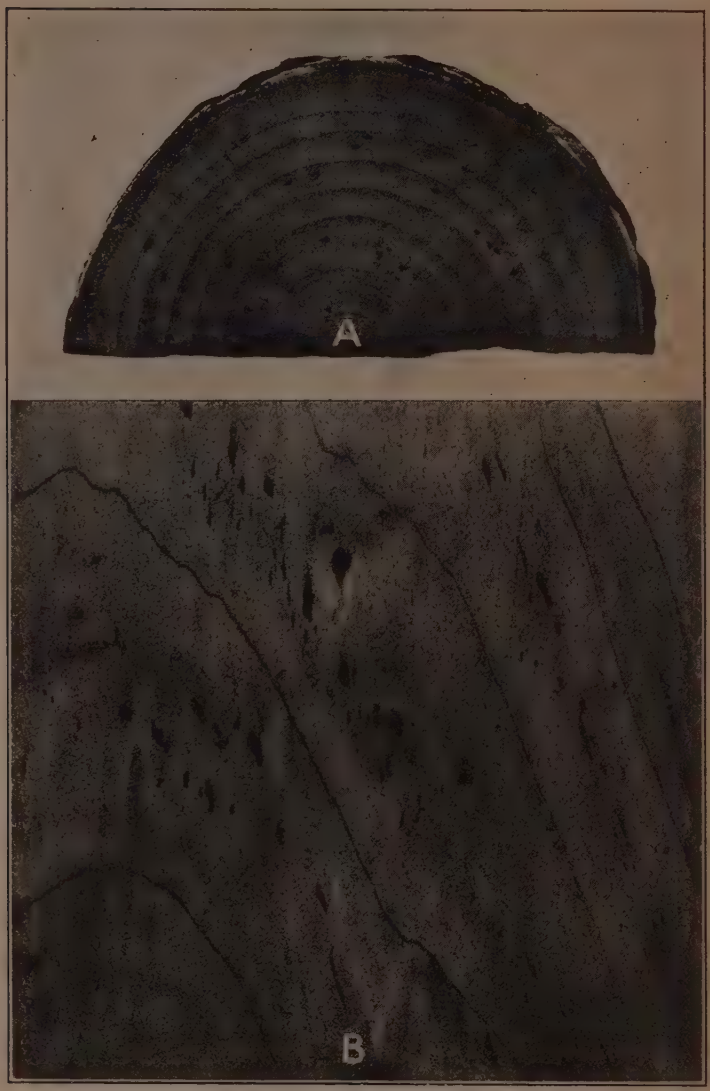

FIG. 45.—A, Pith flecks in river birch, transverse section, caused by *Agromyza pruinosa* (2); B, pith flecks in silver maple, tangential section, caused by *Agromyza aceris*. Natural size

More general and excessive bluing by stain fungi in green lumber after it has been sawn causes a sound defect and is also called "sap stain." Rapid handling of the logs, kiln-drying the lumber, steaming it in a kiln, and air-seasoning are preventive measures. Dipping the lumber in chemical solutions is effective under certain conditions, but this method of prevention has not been entirely satisfactory (*37*, *38*, *40*).

DEFECTS CLASSED AS PITH FLECKS

PITH-FLECK INJURY CAUSED BY THE LARVAE OF FLIES

Birch, cherry, maple, oak, poplar, and many other less commonly used hardwood trees have small "pith flecks," i. e., yellow-brown spots or narrow streaks in the sapwood and heartwood, due to the burrows made by larvae of flies[43] in the cambium of living trees (fig. 45) (*2*, *21*, *22*). This is a very common and widespread defect, more common in soft than in hard maples, and more common in river birch (*Betula nigra*) than in the other birches. Where clear birch is used, as for spool stock, it throws out considerable material. However, this is merely a trade prejudice and should be overcome by educational propaganda, in accordance with the move for closer utilization. This is a sound defect caused in the living tree, the flies laying their eggs in young branches and burrowing down the trunk through the cambium long distances to the roots, where they emerge and pupate. There is no known remedy to prevent the insect injury to the living tree, and hence there is greater need for closer utilization of the product.

PITH-FLECK INJURY CAUSED BY THE FEEDING OF ADULT WEEVILS

Another pith-fleck defect is that caused by the feeding of adult weevils.[44] This defect has been described (*48*) as occurring in fir. The adults puncture the bark to feed on the inner phloem, removing a small circular or oval disk one-fourth inch in diameter to one-fourth by 1 inch. This cavity fills with scar tissue and some gum and later heals over. It is very common in fir, but is not of much commercial importance. No doubt this defect occurs in other trees, as pine and spruce, which are attacked by species of this genus of weevils.

SUMMARY

Defects in timber caused by wood-boring beetles and grubs cause serious losses either by rendering the affected material unfit for use or by reducing it to lower grades.

Much of this loss can be prevented through proper methods of lumbering and management, usually involving but slight changes or modifications in present handling of the timber.

Some of the damage can not be avoided, but in such cases considerable loss can be prevented by periodical inspection and proper classification, piling, and handling of stock. More rapid and closer utilization of the material can often be attained.

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[43] *Agromyza* spp.

[44] *Pissodes dubius* Rand.

This bulletin presents facts which will aid in determining the nature and cause of defects caused by insects, gives recommendations for avoiding preventable injury, and discusses the types of defects which are not preventable. Of course it is not intended to supersede previous classifications of timber and lumber, based on defects other than those due to insects.

The principal damage comes under two types of defects, designated as wormholes, with no living worms or decay, and powder post.

Sound wood can be utilized where the lower price offsets the lower grade and the defect is not objectionable. There will be no extension of the damage after the wood is dry or seasoned. Sound, wormy chestnut even can be exported with no fear of further damage from the insects which caused this defect to the wood of the tree when living.

Powder-posted stock can not be safely utilized because the damage is continuous in the seasoned and finished product and will not only cause further damage but will be a menace to other hardwood stock stored near by.

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